RESISTING NATURAL HAZARDS

1 Purpose

The purpose of this lesson set is to provide students with three levels of involvement with the subject content: to explore building-related threats from natural disasters, to introduce concepts of mitigation strategies; to apply or recommend useful resources for building design. Each is to be engaged in one of three sequenced class sessions.

2 Duration of Lesson

50 Minutes for each session (one per day).

3 Additional Topics

None.

4 Objectives

- Frame an awareness of building-related threats from natural disasters
- Develop an understanding of mitigation strategies.
- Demonstrate an ability to recommend useful resources for building design

5 Standards & Benchmarks

SCIENCE

Advanced Environmental Science

Students investigate, through laboratory and fieldwork, the concepts of environmental systems, populations, natural resources, and environmental hazards. **ENV.1**

Understand and describe that if a disaster, such as flood or fire occurs, the damaged ecosystem is likely to recover in stages that eventually result in a system similar to the original one. **ENV.1.2**

Understand and explain that human beings are part of the Earth's ecosystems, and give examples of how human activities can, deliberately or inadvertently, alter ecosystems. **ENV.1.4**

Cite examples of how all fuels have advantages and disadvantages that society must question when considering the trade-offs among them, such as how energy use contributes to the rising standard of living in the industrially developing nations. However, explain that this energy use also leads to more rapid depletion of Earth's energy resources and to environmental risks associated with the use of fossil and nuclear fuels. **ENV.1.16**

Understand and describe how nuclear reactions release energy without the combustion products of burning fuels, but that the radioactivity of fuels and by-products poses other risks which may last for thousands of years. **ENV.1.32**

Identify natural Earth hazards, such as earthquakes and hurricanes, and identify the regions in which they occur as well as the short-term and long-term effects on the environment and on people. **ENV.1.33**

Biology

Students work with the concepts, principles, and theories that enable them to understand the living environment. They recognize that living organisms are made of cells or cell products that consist of the same components as all other matter, involve the same kinds of transformation of energy, and move using the same kinds of basic forces. Students investigate, through laboratories and fieldwork, how living things function and how they interact with one another and their environment. **B.1**

Describe how ecosystems can be reasonably stable over hundreds or thousands of years. Understand that if a disaster such as flood or fire occurs, the damaged ecosystem is likely to recover in stages that eventually result in a system similar to the original one. (Core Standard) **B.1.39**

AGRICULTURE EDUCATION

Food Science

Risk assessment **FS.7**

Identify and explain the real risks associated with life experiences. **FS.7.1.2**

SOCIAL STUDIES

World Geography

Students will acquire a framework for thinking geographically about the environment and society. They will analyze ways in which humans affect and are affected by their physical environment and the changes that occur in the meaning, distribution and importance of resources. **WG.5**

Map the occurrence and describe the effects of natural hazards throughout the world and explain ways to cope with them. **WG.5.3**

Example: Earthquakes, volcanic eruptions, tornadoes, flooding, hurricanes and cyclones, and lightning-triggered fires

Geography And History Of The World

Students will examine the physical and human geographic factors associated with examples of how humans interact with the environment, such as deforestation, natural hazards and the spread of diseases, and the regional and global consequences of these interactions. **GHW.9**

Use maps to identify regions in the world where particular natural disasters occur frequently. Analyze how the physical and human environments in these regions have been modified over time in response to environmental threats. Give examples of how international efforts bring aid to these regions and assess the success of these efforts. **GHW.9.1**

Example: Japan (earthquakes): building reinforced skyscrapers, training for emergency in a disciplined society; United States (hurricanes): the response in Florida and Louisiana, government aid, flood-prone areas in urban environment; Indian Ocean (earthquakes, tsunamis): lack of warning systems in the third world countries, worldwide relief efforts, foreign aid; Colombia (volcanoes): mud-flows, government response in remote areas of the world; Pakistan (earthquakes): remote areas, lack of building codes, terrorist activity; and China (floods): deadly floods on the Hwang Ho River

GHW.9.2

Identify regional resource issues that may impede sustainability, economic expansion and/or diversification. Assess the impact of these issues on the physical and human environments of specific regions. Propose strategies for dealing with regional resources issues.

Example: United States: distribution of fresh water in western states, California vs. neighboring states; African Sahel: overgrazing vegetation, compounding effects of drought and consequent desertification; Europe: dependence on the Persian Gulf for fossil energy; Russia: significant resource potential, but slow development of infrastructure and residuals of command economy within the market economy since the 1990s.

GHW.9.3

Identify and describe ways in which humans have used technology to modify the physical environment in order to settle areas in different world regions. Evaluate the impact of these technologies on the physical and human environments affected.

Example: Netherlands: use of dams and dikes to claim polderlands from the North Sea; United States (New Orleans): levees and dams used for urban growth and development; China: Three Gorges Dam on Yangtze River causing displacement of population and changing the land features, but also providing great potential for modernization; Southwest Asia (Qatar and United Arab Emirates): changing the desert into areas of agriculture productivity and developing urban centers.

GHW.9.4

Distinguish and assess the human and physical factors associated with the spread of selected epidemics and/or pandemics over time and describe the impact of this diffusion on countries and regions. Propose strategies for limiting the spread of diseases.

Example: Europe (Black Death, Bubonic Plague): spread from Central Asia, dramatic decrease in population (fourteenth century); North America (Native Americans): Europeans bringing smallpox and measles to New World (1500s); World: the cholera pandemic (1700-1800s), Influenza Pandemic (1918-1919), the AIDS epidemic (1900s); Asia and United States: the potential for a bird flu pandemic and the response by the United States with the help of the Centers for Disease Control (2007).

6 Vocabulary

Earthquakes-Building design will be influenced by the level of seismic resistance desired. This can range from prevention of nonstructural damage in frequent minor ground shaking to prevention of structural damage and minimization of nonstructural damage in occasional moderate ground shaking, and even avoidance of collapse or serious damage in rare major ground shaking. These performance objectives can be accomplished through a variety of measures such as structural components like shear walls, braced frames, moment resisting frames, and diaphragms, base isolation, energy dissipating devices such as visco-elastic dampers, elastomeric dampers, and hysteretic-loop dampers, and bracing of nonstructural components.

Hurricanes, Typhoons, and Tornadoes-The key strategy to protecting a building from high winds caused by tornados, hurricanes, and gust fronts is to maintain the integrity of the building envelope, including roofs and windows, and to design the structure to withstand the expected lateral and uplift forces. For example, roof trusses and gables must be braced; hurricane straps must be used to strengthen the connection between the roof and walls; and doors and windows must be protected by covering and/or bracing. When planning renovation projects, designers should consider opportunities to upgrade the roof structure and covering and enhance the protection of fenestration. The Additional Resources section of this page includes several FEMA publications for designing community shelters, constructed to protect a large number of people from a natural hazard event, and "residential safe rooms" for occupant refuge during windstorms.

Flooding-Flood mitigation is best achieved by hazard avoidance—that is, proper site selection away from floodplains. Should buildings be sited in flood-prone locations, they should be elevated above expected flood levels to reduce the chances of flooding and to limit the potential damage to the building and its contents when it is flooded. Flood mitigation techniques include elevating the building so that the lowest floor is above the flood level; dry flood-proofing, or making the building watertight to prevent water entry; wet flood-proofing, or making uninhabited or non-critical parts of the building resistant to water damage; relocation of the building; and the incorporation of levees and floodwalls into site design to keep water away from the building.

Rainfall and Wind-Driven Rain-One of the primary performance requirements for any building is that it should keep the interior space dry. All roofs and walls must therefore shed rainwater, and design requirements are the same everywhere in this respect. For example, roof drainage design must minimize the possibility of ponding water, and existing buildings with flat roofs must be inspected to determine compliance with this requirement. Recommendations for addressing rainfall and wind-driven rain can be found in the International Building Code (IBC) series.

Differential Settlement (Subsidence)-Ground subsidence can result from mining, sinkholes, underground fluid withdrawal, hydro-compaction, and organic soil drainage and oxidation. Subsidence mitigation can best be achieved through careful site selection, including geotechnical study of the site. In subsidence-prone areas, foundations must be appropriately constructed, basements and other below-ground projections must be minimized and utility lines and connections must be stress-resistant. When retrofitting structures to be more subsidence-resistant, shear walls, geo-fabrics, and earth reinforcement techniques such as dynamic compaction can be used to increase resistance to subsidence damage and to stabilize collapsible soils.

Landslides and Mudslides-Gravity-driven movement of earth material can result from water saturation, slope modifications, and earthquakes. Techniques for reducing landslide and mudslide risks to structures include selecting non-hillside or stable slope sites; constructing channels, drainage systems, retention structures, and deflection walls; planting groundcover; and soil reinforcement using geo-synthetic materials, and avoiding cut and fill building sites.

Forest Fires-As residential developments expand into wild land areas, people and property are increasingly at risk from wildfire. Fire is a natural process in any wild land area and serves an important purpose; however, if ground cover is burned away, erosion, landslide, mudflow, and flood hazards can be exacerbated. A cleared safety zone of at least 30 feet (100 feet in pine forests) should be maintained between structures and combustible vegetation, and fire-resistant ground cover, shrubs, and trees should be used for landscaping (for example, hardwood trees are less flammable than pines, evergreens, eucalyptus or firs). Only fire-resistant or non-combustible materials should be used on roofs and exterior surfaces. Roofs and gutters should be regularly cleaned and chimneys should be equipped with spark arrestors. Vents, louvers, and other openings should be covered with wire mesh to prevent embers and flaming debris from entering. Overhangs, eaves, porches, and balconies can trap heat and burning embers and should also be avoided or minimized and protected with wire mesh. Windows allow radiated heat to pass through and ignite combustible materials inside, but dual- or triple-pane thermal glass, fire-resistant shutters or drapes, and noncombustible awnings can help reduce this risk.

Tsunami-A tsunami is a series of ocean waves generated by sudden displacements in the sea floor, landslides, or volcanic activity. In the deep ocean, the tsunami wave may only be a few inches high. The tsunami wave may come gently ashore or may increase in height to become a fast moving wall of turbulent water several meters high. Although a tsunami cannot be prevented, the impact of a tsunami can be mitigated through urban/land planning, community preparedness, timely warnings, and effective response.

7 Materials

Computer in classroom with internet connection;

Audio and Video Output Devices for the Computer;

In-class Worksheets and Handouts

8 Additional Resources

None.

9 Procedures & Methods

A. Introduction

Buildings in any geographic location are subject to a wide variety of natural phenomena such as windstorms, floods, earthquakes, and other hazards. While the occurrence of these events cannot be precisely predicted, their impacts are well understood and can be managed effectively through a comprehensive program of hazard mitigation planning.

Mitigation refers to measures that can reduce or eliminate the vulnerability of the built environment to hazards, whether natural or man-made. The fundamental goal of mitigation is to minimize loss of life, property, and function due to disasters. Designing to resist any hazard(s) should always begin with a comprehensive risk assessment. This process includes identification of the hazards present in the location and an assessment of their potential impacts and effects on the built environment based on existing or anticipated vulnerabilities and potential losses. Mitigation is local; standards are national.

It is common for different organizations to use varying nomenclature to refer to the components of risk assessment. For example, terrorism and foreign military power are referred to as "threats" by the intelligence community, while hurricanes and floods are referred to as "hazards" by emergency managers; however, both are simply forces that have the potential to cause damage, death, and injury, and loss of function in the built environment. Regardless of who is conducting the risk assessment, the fundamental process of identifying what can happen at a given location, how it can affect the built environment, and what the potential losses could be, remains essentially the same from application to application.

Only after the overall risk is fully understood should mitigation measures be identified, prioritized, and implemented. Basic principles underlying this process include:

- The impacts of natural hazards and the costs of the disasters they cause will be reduced whether mitigation measures are implemented pre-disaster (preventively) or post-disaster (correctively). Proactively integrating mitigation measures into new construction is always more economically feasible than retrofitting existing structures.

- Risk reduction techniques must address as many applicable hazards as possible. This approach, known as multi-hazard mitigation, is the most Cost-Effective approach, maximizes the protective effect of the mitigation measures implemented, and optimizes multi-hazard design techniques with other building technologies.

Mitigation of existing facilities. Mitigation is based on localized design criteria in accordance with UFC 3-310-01 and established facility renovation triggers. Mitigation for multiple requirements, for example seismic and force protection, are most effective when addressed simultaneously.

B. Development

Day #1

Students should be asked to read through the definitions of Natural Disasters. Students then should be asked to brainstorm in different groups which of these many disasters could be a threat to an airport in the Midwest (or elsewhere if the teacher chooses).

C. Practice

Day #2

Students are divided into eight groups and each group is to select one of eight natural disasters. Each group is asked to use the reference and supplemental materials to prepare a short presentation on the selected natural disaster as a threat to an airport terminal.

D. Independent Practice

Day # 3

Students are asked independently to select one of the disasters and to imagine where and how they could try to mitigate the natural disaster should one threaten their chosen airport. They should share their ideas with classmates to compare the similarity of their mitigation techniques.

Students then should be asked to brainstorm in three different groups what recommendations they would make to implement a first response to a natural disaster hitting their chosen airport, including the building site, building and building spaces and the steps to be followed by the airport authority working in collaboration with local government, Homeland Security, and FEMA.

E. Accommodations (Differentiated Instruction)

Some students may be most skillful researching the scientific basis and technical aspects of a respective natural disaster threat and its mechanism of human incapacitation.

Some students may be most comfortable with diagramming the physical layout of the airport and locating points of vulnerability to a natural disaster threat.

Some students may have a natural affinity for illustrating the mitigation techniques to be used to thwart the negative impact of a natural disaster on an airport.

Some students might be most adept at organizing a team presentation and writing/editing the narrative of the team report to be made to the rest of the class.

F. Checking For Understanding

No matter what distinctive task a student embraces as a team member and as an individual, she/he should be able to demonstrate a comprehensive understanding by the recount and summation of all that has been presented by all teams. In sharing in a class discussion, the teams may determine if one of the plans provides the best mitigation of the threat. Another option would be for students to look for commonalities and as well as uniqueness among the plans. A discussion may ensue concerning best practices for airports to use in thwarting the negative impact of a natural disaster.

G. Closure

Students should document their experience in final report form and annotating their rationale for the natural disaster diagnoses, recommendations and modifications.

10 Evaluation

Students are to be evaluated on the clarity with which they present the content of their reports, Including:

Concise but thorough writing;

Annotation of appropriately excerpted/constructed illustrations;

Logic and organization of the presentation;

Quality of the report formatting.

11 Teacher Reflection

To be completed by the teacher after teaching the lesson.

12 Resources & Media

Computer in classroom with internet connection;
Audio and Video Output Devices for the Computer;
In-class Handouts
Supplemental material

Publications
Anthrax-Contaminated Facilities: Preparations and a Standard for Remediation (PDF 82 KB, 19 pgs) by the Congressional Research Service. 2005.

Federal Agencies and Programs
Consumer Products Safety Commission
National Institute for Occupational Safety and Health (NIOSH)—The Federal agency responsible for conducting research and making recommendations for the prevention of work-related disease and injury. The Institute is part of the Centers for Disease Control and Prevention (CDC).
National Resource Center for Health and Safety in Child Care
Occupational Health and Safety Administration (OSHA)
OSHA Emergency Preparedness/Planning Info
OSHA eTools and Electronic Products for Compliance Assistance
OSHA Legionnaires' Disease Design Guidance

Standards and Code Organizations
American National Standards Institute (ANSI)
ASTM International
American Society of Mechanical Engineers (ASME)
FM Global
International Code Council, Inc. (ICC)
International Organization for Standardization (ISO)
National Electrical Contractors Association (NECA)
National Fire Protection Association (NFPA)
Underwriters Laboratories Inc. (UL)

Associations and Organizations
American Society of Safety Engineers (ASSE)
Human Factors and Ergonomics Society
Institute for Safety Through Design (ISTD)—Established in 1995 by the National Safety Council's Business and Industry Division, the Institute works toward improving the design and development of all processes involved in industrial operations, including equipment, tooling, products, work methods, training, facilities, systems, and delivery of services.
National Safety Council (NSC)—A leading source of safety and health information in the United States.
Others
RiskWorld